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Review of Literature

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This review highlights the critical role of patient-centered diagnostic care (PCC) in enhancing healthcare quality, focusing on its core principles of dignity, personalized care, and patient empowerment. PCC fosters partnerships between healthcare providers and patients, aiming to improve patient satisfaction, self-care abilities, and health outcomes while reducing hospitalization rates. A central element of PCC is accurate and timely diagnosis, facilitated by laboratory diagnostics, which play a crucial role in disease detection, risk assessment, and personalized treatment. Effective diagnostic processes rely on precise patient preparation, specimen collection, and handling, underscoring the importance of quality assurance and error minimization in laboratory medicine.

The review also emphasizes the collaborative role of nursing and laboratory staff in achieving high-quality diagnostic care. Nurses bridge communication between clinicians, patients, and laboratories, coordinating test requests, results, and patient preparation. Interprofessional collaboration enhances diagnostic accuracy, treatment efficacy, and patient satisfaction. Additionally, the implementation of shared protocols and guidelines between nursing and laboratory teams promotes consistent care, minimizes errors, and fosters a collaborative environment.

Technological advancements, particularly artificial intelligence (AI), have transformed laboratory diagnostics by automating processes, managing large datasets, and facilitating personalized medicine. AI applications in clinical labs streamline sample identification, quality control, and result interpretation, contributing to error reduction and efficiency in diagnostics. Despite AI's potential, ethical considerations and accessibility remain challenges.

Best practices in laboratory testing emphasize patient safety, focusing on quality assurance throughout the Total Testing Process (TTP). Effective specimen management and risk management strategies are essential in ensuring diagnostic reliability. The integration of PCC, interprofessional collaboration, and AI-driven advancements positions laboratory diagnostics as a cornerstone of modern healthcare, supporting a holistic, patient-focused approach that aligns with evolving healthcare demands.

Keywords: Patient-centered care (PCC), Diagnostic accuracy, Laboratory diagnostics, Interprofessional collaboration, Specimen management, Healthcare quality, Nursing and laboratory collaboration

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Chapter 1: Introduction to Patient-Centered Diagnostic Care

There is increasing recognition of the significance of patient-centered care (PCC) within healthcare settings (Yu et al., 2023). The Health Foundation defines PCC as a collaborative effort between health and social care professionals and the individuals they serve. It emphasizes four core principles: treating individuals with dignity, compassion, and respect; providing coordinated care, support, or treatment; delivering personalized services; and enabling individuals to recognize and develop their strengths to lead independent, fulfilling lives (Hyde & Hardy, 2021).

PCC creates partnerships among healthcare practitioners, patients, and their families, ensuring that patients' needs, values, and preferences are prioritized (Gagliardi et al., 2019). Key characteristics of PCC include empathy, respect, engagement, effective communication, shared decision-making, and a holistic approach. Such partnerships are strengthened by information sharing, empathy, and empowerment, with a focus on case management and patient empowerment in health promotion (Eklund et al., 2019).

Moreover, PCC is essential for high-quality healthcare, resulting in numerous positive outcomes: improved health knowledge, enhanced self-care skills, greater satisfaction, better medication adherence, higher quality of life, and reduced hospital admissions and stays (Park et al., 2018). For family members, PCC decreases stress, anxiety, and depression, fosters satisfaction, and improves interactions with healthcare providers. Additionally, PCC benefits the healthcare system by promoting cost-effective services (Marques et al., 2021).

Accurate and timely diagnosis is critical for patient care, research, and policy. Diagnosis serves as both a process and a classification system, helping healthcare providers identify specific conditions. An accurate diagnosis allows for tailored clinical decisions, leading to the best possible health outcomes for patients (Mirbabaie et al., 2021). Diagnostic testing, which includes x-rays, scans, and blood work, plays a key role in confirming health conditions (Cheng et al., 2020).

Diagnostic investigations are fundamental to patient care, as clinical decisions largely depend on the accuracy and interpretation of these tests. The advancement of modern laboratory instruments has improved diagnostic precision, yet awareness of factors that may impact results remains essential (Nydegger & Lung, 2023). The diagnostic process is intricate, patient-focused, and collaborative, involving the collection of information and clinical reasoning to accurately identify a patient's health issue within a larger healthcare system that shapes this process (Martyushev-Poklad et al., 2022).

This process follows a decision-making model that cycles through data gathering, integration, and interpretation, forming a working diagnosis. Patient-centered diagnosis thrives through shared decision-making, an ongoing dialogue between the physician and patient that respects individual needs, values, and preferences (Fonseca et al., 2023). Laboratory diagnostics play a key role in modern medicine, supporting early detection, risk identification, prognosis, and personalized treatment plans (Plebani, 2023).

Patient-centered diagnostic care is essential, fostering an environment where healthcare providers reflect on practice decisions, enhancing both professional growth and collaborative goal setting. This approach improves disease management, treatment adherence, and reduces patient anxiety, ultimately empowering patients to participate actively in their care (Grover et al., 2022).

The Total Testing Process (TTP) is a framework designed to guide and minimize errors across laboratory and clinical settings. This model incorporates internal and external lab activities requiring collaboration among nursing staff, phlebotomists, doctors, and laboratory personnel, all working as a cohesive team to ensure optimal patient care (Sonmez et al., 2020). Nurses, in particular, are responsible for conveying test results to those needing the information promptly (Arifin & Mohd-Yusof, 2022). Globally, nurses play a crucial role in patient care, often providing direct care under physicians' guidance. In many settings, nurses coordinate the diagnostic process, including laboratory test requests and results management. In some areas, nurses also serve as primary diagnosticians, requesting and interpreting lab tests as necessary (Namuhani et al., 2023).

Nurses facilitate communication between physicians and patients, helping patients take a proactive role in their care. They gather and assess both subjective and objective data, monitoring diagnosis accuracy and intervening to prevent errors. Nurses are often the first to observe patient deterioration and respond, especially in acute and long-term care environments (Gleason et al., 2021). Nurses also meet patient needs for information about their tests, addressing questions and alleviating anxieties. Most laboratory tests are minimally invasive and require implied informed consent; while some patients express little interest, others seek understanding of their tests and results (Millum & Bromwich, 2021; Oermann et al., 2023).

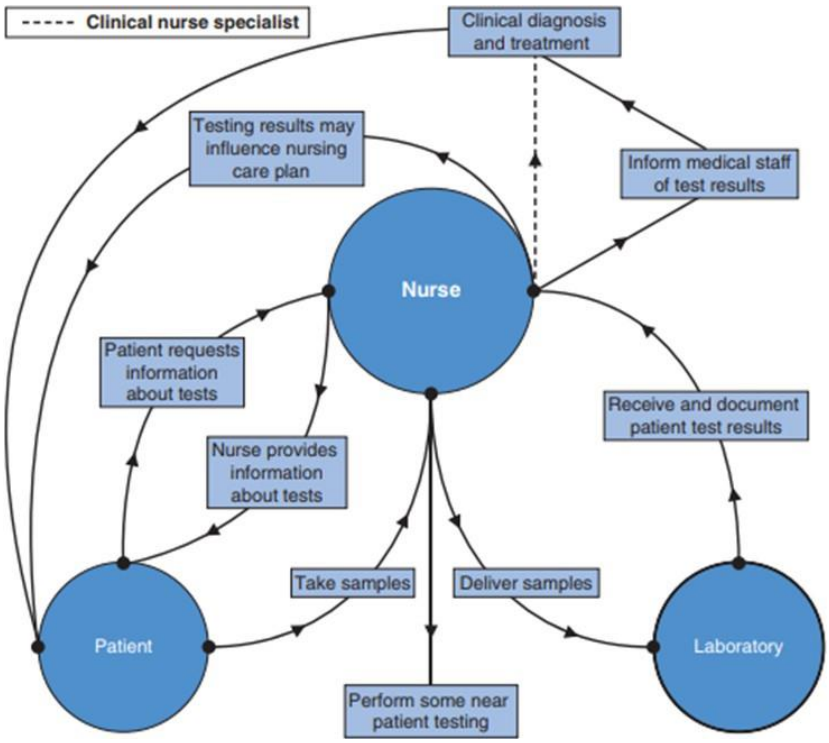

Figure (1): Nursing staff involvement in testing of patient samples

Higgins, C. (2012). *Understanding laboratory investigations: A guide for nurses, midwives and health professionals*. John Wiley & Sons. 3rded.pp.4

Nurses play a crucial role in preparing patients for diagnostic testing. This includes tasks like drawing blood, administering medications, collecting and sending specimens like sputum or urine to the lab, and preparing specific areas by sterilizing or shaving them for surgical procedures or electrode placement

(Unger & Kucia, 2022). They also help patients mentally prepare by answering questions and explaining the procedures and potential outcomes (Perry et al., 2021).

During diagnostic tests, nurses support both patients and healthcare providers. They may administer medications as needed, help position patients correctly, and transport them to and from testing sites, ensuring they arrive safely and on time (Karaca & Durna, 2019). Nurses are often responsible for gathering and preparing equipment, ensuring it's functional and sanitized before and after each use to prevent infection. They assist technicians to make testing smooth and report any damaged equipment to prevent its use until repaired (Griffin et al., 2020; Dresser et al., 2023).

Nurses monitor patients' medical conditions throughout testing, especially for those deemed unstable, by checking vital signs and watching for any changes on monitors like heart monitors or ventilators. They might need to connect or disconnect devices that could interfere with tests (Poncette et al., 2020). The collection and safe, timely transport of samples also fall under nursing duties. Nurses should follow best practices in this pre-testing phase, and they are often involved in receiving laboratory results, understanding lab report terminology, and identifying abnormal results needing immediate attention. Nurses have performed limited tests, like blood glucose and urine dipstick testing, in various clinical settings for years (Arifin & Mohd-Yusof, 2022; Jalavu et al., 2020).

With technological advances, many tests can now be conducted on-site in clinics and wards, especially in ICU, coronary, and emergency settings, where quick analysis benefits patient care. Nurses involved in this testing must understand the limitations and clinical relevance of their work (Iavich & Sharvadze, 2022; Jalloh et al.,). Though traditionally doctors handled ordering and interpreting lab tests, clinical nurse specialists now participate in these tasks. All nursing staff must consider how lab results might influence patient care plans (Htay & Whitehead, 2021). Nurses are also responsible for reporting results to doctors and specialists through phone, fax, or electronic systems and may input results into patient records. They are required to notify physicians of critical abnormalities, such as dangerous potassium levels, that need immediate response (Lukewich et al., 2022; Truijens et al., 2023).

Chapter 3: Laboratory Processes: From Sample Collection to Diagnosis

Laboratory tests are essential in providing critical insights into a patient's health, and accurate diagnostic and therapeutic decisions rely on the reliability of test results (Morgan et al., 2021). Proper patient preparation, careful specimen collection, and correct specimen handling are key to ensuring accurate test outcomes. A good-quality specimen involves four stages: patient preparation, specimen collection, specimen processing, and storing or transporting the specimen (González-Domínguez et al., 2020).

Step 1: Patient Preparation and Identification – Before each collection, healthcare providers should review the test details, including the type and volume of the specimen, collection procedures, and storage requirements (Bonizzi et al., 2022). Preparing the patient involves explaining the purpose and steps of the procedure to ensure their comfort and cooperation, thereby facilitating a smoother collection process (Griesemer et al., 2021). Patients should be provided in advance with necessary instructions regarding fasting, dietary, or medication restrictions relevant to the specific test.

Patient Identification is also crucial (Jayamohan et al., 2021). Confirming the patient's identity with at least two identifiers, such as name and date of birth, safeguards against errors, ensuring that each specimen is correctly linked to the intended patient, thus preventing diagnostic mistakes. Ideally, specimens should be collected when the patient is in a basal state, generally in the early morning after approximately 12–14 hours of fasting (Unar et al., 2023). Blood composition changes after meals due to nutrient absorption, making post-meal samples unsuitable for certain chemistry tests. An overnight fast, starting from 6 PM the previous evening, is recommended to keep the patient in the basal state and minimize dietary influences on test results.

Before collecting the specimen, it is crucial to confirm the patient's last food or drink intake. If the patient has recently eaten but the test must proceed, this should be marked as "nonfasting" on the test request form

(Small et al., 2022). In such cases, the time of the last meal should be noted in the test request comments. Fasting does not exclude water consumption, and dehydration from water restriction can affect test outcomes (Cui et al., 2022). For non-basal state specimens, additional factors like recent physical activity, which may elevate blood glucose, lactic acid, serum proteins, and creatine kinase (CK) levels, should be considered when interpreting results (Kiselica et al., 2023).

Emotional or physical stress can lead to variations in test results, and factors such as the patient's clinical condition, diurnal fluctuations, and circadian rhythm changes may impact outcomes as well (Lippi et al., 2020). When preparing specimens, it is essential to verify patient identification accurately. Proper identification of specimens is crucial, requiring that all primary containers be labeled with at least two identifiers at the time of collection. While submitted slides may sometimes be labeled with only one identifier, two are generally recommended. Acceptable identifiers might include the patient's full name as it appears on the test request form, date of birth, hospital number, test request form number, accession number, or a unique random identifier (Nakhaie et al., 2023).

A location, such as a hospital room number, does not qualify as an appropriate patient identifier. If a chain of custody is required, the correct protocol must be followed. Specimens should always be labeled in the presence of the patient to ensure accuracy. Proper processing and storage are essential to preserving the specimen's integrity and the reliability of the test results (Smith et al., 2020). Careful adherence to routine procedures can prevent most potential issues associated with specimen collection (Kazantseva et al., 2021).

Laboratories provide specific materials for specimen collection, which help maintain specimen quality only if used exactly according to provided instructions. Refer to the volume requirements to ensure the correct quantity of each specimen is collected for the procedures intended (Björndahl & Brown, 2022). General specimen collection principles include verifying that collection and transportation supplies are not expired (Wahidi et al., 2020).

Correct labeling is vital, and all relevant information must be provided on the test request form. Ensure the specimen quantity is adequate to conduct the test, avoiding a "quantity not sufficient" (QNS) designation, as outlined in test requirements. Use the recommended container or tube for specimen preservation, and follow any patient-specific instructions, including the order of blood draw if multiple tubes are needed. Make sure specimen lids are securely tightened to prevent leakage and contamination. Adhere to the temperature requirements specified for transportation, and mix specimens with additives immediately after collection by inverting them 5–10 times (Kitchen et al., 2021).

For serum preparation, several key considerations apply. Serum should be separated from red blood cells within two hours of venipuncture, and specimens with additives should be mixed by inverting them immediately after collection. Allow blood collected in clot tubes (such as red-top or gel-barrier tubes) to clot before centrifugation. Avoid hemolysis, where red blood cells break down and release components into the serum. Additionally, lipemia, a cloudy or milky appearance sometimes due to the patient's diet, should be prevented (Waxman & Lind, 2023).

In preparing plasma, adhere to the following recommendations: collect specimens in the indicated additive, and mix by inverting immediately after collection to prevent red blood cell breakdown. Fill the tube to capacity to avoid an excessive dilution factor. Separate plasma from cells within two hours of venipuncture, or follow the time requirements specified. Label transport tubes as "plasma," and indicate the type of anticoagulant used (e.g., "EDTA," "citrate") (Wilkinson et al., 2023).

Urine Collection, the most common urine collection considerations include: Obtain a clean-catch, midstream specimen. Store unpreserved specimens refrigerated or in a cool place until ready for transport. Provide patients with instructions for 24-hour urine collection(s) (Leaver, 2022). Add the preservative (as specified in the test requirements) to the urine collection container prior to collection of the specimen if the preservative is not already in the container. Provide sufficient quantity of specimen to meet the minimum fill line on preservative transport container (Erdbrügger et al., 2021).

To ensure proper handling of specimens, follow the specified guidelines for mixing with the appropriate preservative (A't Hoen et al., 2021). Use the designated collection container and refrigerate the specimen if it's required for bacteriological examination. Ensure container lids are tightly closed to prevent leakage, and divide samples as needed for specific tests. Provide a complete 24-hour collection or aliquot, and specify the total urine volume if only an aliquot from a 24-hour collection is submitted. Each test may require a different preservative, so refer to the test information for details (Aulakh et al., 2020).

Step 2: Specimen Collection – After preparing and identifying the patient, proceed with specimen collection, following the procedure based on the sample type. Blood is commonly collected through venipuncture, where a needle is inserted into an arm vein, allowing blood to flow into a collection tube (Roy-Chowdhuri et al., 2020; Delahaye et al., 2021). For urine samples, a "clean catch" method is often used, where the patient collects midstream urine in a sterile container to reduce contamination. Collection of sputum, swabs, or catheter samples follows specific protocols to maintain sample integrity (Qian et al., 2020). To prevent cross-contamination, healthcare professionals must wash their hands before and after each procedure, ensuring samples accurately reflect the patient's health (Misra et al., 2020).

For vacuum tubes with additives (e.g., anticoagulants, preservatives), gently tap the tube to release any additives stuck to the sides, fill the tube completely to ensure the proper blood-to-additive ratio, and invert slowly 4–8 times to mix (Shajani-Yi & Nichols, 2020). Avoid rapid shaking to prevent hemolysis, and check for undissolved additives, inverting as needed until dissolved. For multiple samples, invert each one immediately after collection and place tubes upright as soon as possible. Gel-barrier tubes should be inverted 5–6 times and left to stand for 30–60 minutes before centrifugation (Lindström, 2021; Jiang et al., 2021).

Vacuum Tubes without Anticoagulants should be allowed to fill completely, stand for 30–60 minutes (but no longer than 60), and then be centrifuged according to the manufacturer's guidelines (Krabbe et al., 2020). Hemolysis, or the breaking of red blood cells, can often be avoided by adhering to proper techniques, as hemolyzed serum or plasma appears pink or red instead of clear (Gosselin et al., 2021). Routine collections typically use a 21- to 22-gauge needle, but a 23-gauge needle may be used for elderly or pediatric patients with smaller veins. If there is a loss of vacuum or air leakage around the needle, replace the tube. When using non-vacuum equipment, ensure all materials are clean, dry, and sterile. Blood samples should be collected in room-temperature containers unless specified otherwise. Difficulty accessing veins or slow filling can cause damage to red blood cells (Gosselin, 2021; Lima-Oliveira et al., 2021).

To address issues in blood collection, if blood flow is interrupted, use a fresh tube or choose a new puncture site and employ sterile, unused equipment to collect a second sample. Using a blood pressure cuff instead of a tourniquet can help reduce trauma to delicate red blood cells (Steiner et al., 2022). Avoid removing the needle from the vein while the vacuum tube is still engaged, as this applies to the last tube in a routine collection as well as difficult draws. Premature removal can allow air to enter the tube and potentially damage red cells (Siegal et al., 2023).

Handle the blood collection gently, drawing the blood smoothly and without excessive pressure. Avoid forcefully transferring blood from a syringe to a tube, as this can damage red cells. Allow the puncture site to dry after cleaning with alcohol to avoid contamination in the tube (Bloor, 2021). Do not collect samples from or through a hematoma, and ensure the specimen clots fully (30 to 60 minutes) before centrifuging. Centrifuge the specimen for no more than 10 minutes unless specified otherwise in the collection guidelines (Griesemer et al., 2021).

For Lipemic Serum or Plasma (characterized by turbidity), normal serum or plasma is typically clear and light yellow to straw-colored. However, cloudy or milky serum may be due to bacterial contamination or high lipid levels from the patient's diet, especially within 24 hours before collection (Jones et al., 2023). Foods rich in lipids, like meats, butter, cream, and cheese, can elevate lipid levels temporarily, causing lipemic serum, which may not accurately represent the patient's physiological state (Benson,2023).

Some patients, regardless of diet or fasting duration, may naturally produce cloudy specimens. To avoid dietary-induced high lipid levels before testing, physicians often advise patients to avoid high-fat foods or fast for 12-14 hours before collection. For morning specimens, fasting from 6 PM the previous evening is recommended (Block & Genzen, 2020).

Quantity Not Sufficient (QNS) is a common issue when the volume of the specimen is too low for testing, leading the lab to mark the sample as QNS and requiring a repeat collection, which can be inconvenient for patients and healthcare providers (Brander et al., 2020). To avoid this, draw at least 2.5 times the serum volume needed; for example, if 2 mL of serum is required, draw at least 5 mL of blood. For complex testing profiles, draw at least two 8.5-mL gel-barrier tubes, or, for pediatric cases, collect enough to meet testing needs (Serdar et al., 2021). Provide appropriate containers and instructions for 24-hour urine and stool collections (Binnicker, 2020). The specimen collection process is crucial to patient care, significantly impacting disease diagnosis, treatment planning, and health monitoring (Lakens, 2022).

Specific Collection Procedures vary depending on the sample type. Phlebotomy, for example, is typically used to collect whole blood samples. The healthcare professional must wash hands, use sterile collection containers like Vacutainers, and avoid actions that could cause hemolysis, which may alter test results (Di Lorenzo & Strasinger, 2022).

Urine Collection: Urine samples are often collected using a clean-catch midstream method. Patients are instructed to wash their hands and cleanse their genital area with a wipe before collecting the "midstream" portion of urine in a sterile container to minimize contamination from bacteria around the genital area (Llor et al., 2023). Swab Collection: Swabs are used to gather samples from areas like the throat, nose, skin, or wounds. A sterile swab collects cells or other material, and if the sample needs to be transported to an off-site lab, a swab with transport media should be used (Burgess, 2022).

Special Considerations in Specimen Collection: Certain samples require special handling during collection. For instance, blood cultures need strict aseptic techniques to prevent contamination, and sputum samples must come from deep within the lungs without including saliva (Glogowska et al., 2023). Microbiology samples often have stringent timing and transportation requirements to maintain microorganism viability. Biopsy samples, or tissue specimens, should be placed immediately in a preservative to preserve cellular structure (Stærk et al., 2023).

Common Challenges and Solutions in Specimen Collection: Despite protocols, specimen collection can face various challenges that may affect sample quality and test results (Tawfik et al., 2022).

- **Patient Anxiety**: Many patients feel anxious about specimen collection, especially when needles are involved, such as in venipuncture. Anxiety can cause muscle tension, making it harder to locate veins, or may lead to patient movement, affecting sample collection (Khalid & Nasir et al., 2022). Healthcare providers can help by reassuring patients, explaining the procedure clearly, and using distraction techniques. A calm, empathetic approach can ease anxiety, leading to smoother collection (Bharti & Grimm, 2021).
- **Difficulty Locating Veins**: Finding a suitable vein for venipuncture can be challenging, especially in elderly, pediatric, or certain medical patients. Techniques like applying a warm compress to the area may make veins more visible, or alternate collection sites may be considered (Al-Saadi et al., 2021).
- **Contaminated Samples**: Contamination can occur during collection, handling, or transport, leading to inaccurate results. Urine samples, for example, may be contaminated if the clean-catch method is not followed. Strict aseptic techniques, using sterile containers, and ensuring proper hand hygiene can reduce contamination risk (Lockwood & Sharp, 2020).
- **Hemolysis in Blood Samples**: Hemolysis, the rupture of red blood cells, can occur during collection or handling, affecting test results. Proper needle size, minimal agitation, and maintaining correct additive-to-blood ratios can prevent hemolysis (Ragavan et al., 2023).

- **Improper Labeling or Documentation**: Mislabeling samples or errors in documentation can lead to misidentification or inappropriate testing. Double-checking systems, barcoding, and regular training for healthcare workers can help ensure accurate labeling and documentation (Moiz et al., 2020).

For tubes containing additives, it is essential to fill them to the marked "fill line" to ensure the correct blood-to-additive ratio, as an insufficient fill can result in a QNS (Quantity Not Sufficient) specimen (Bhasker, 2021).

Specimen Storage and Shipping Temperatures: Defined temperatures are used for storing and transporting specimens: Room temperature (10.1 – 40.0 °C), refrigerated (1.0 – 10.0 °C), and frozen (-1.0 to -80.0 °C). There are two main types of timed blood specimens. The first type is a single specimen drawn at a specific time, such as fasting plasma glucose to diagnose diabetes. Fasting is defined as no caloric intake for at least eight hours. A postprandial glucose test may be ordered two hours after a meal for diabetes screening (Jagannathan et al., 2020). Blood cultures may be timed to check for infections, and specific timing is also critical for therapeutic monitoring of medications (Sacks et al., 2023).

Multiple timed specimens may be required for tests like the glucose tolerance test, where a fasting specimen is first collected, then blood samples are taken at set intervals after glucose ingestion (Jamieson et al., 2023). Similar protocols apply to the tolbutamide test, or for medication effect testing on consecutive days. Sequential blood or urine sampling may help diagnose endocrine diseases (Elangovan et al., 2023).

Serial Monitoring: Monitoring over time, such as for tumor markers, involves repeated sampling. Instructions for serial monitoring are provided in the test description (Gouda et al., 2022). Interference from Medications and Other Substances, prescription and over-the-counter drugs can interfere with test results by affecting levels of certain substances. This interference varies by method, so physicians must advise patients on medications to avoid before collection (Fang et al., 2023).

If a patient cannot discontinue the medication that may interfere with testing, this should be noted on the test request form. Drugs and their metabolites can often be concentrated in urine to levels that significantly interfere with urine assays. Notable clinical cases of drug interference include those seen with thiazide diuretics, which can cause hyperuricemia and hyperglycemia, and catecholamine assays, where, if a 24-hour drug abstinence period is not possible, metanephrines should be ordered instead (Mouliou & Gourgoulianis, 2021; Ferrari et al., 2021).

Oral contraceptives also impact laboratory tests, as they can reduce serum vitamin B12 levels, resembling vitamin B12 deficiency. Additionally, they increase thyroxine-binding globulin in the serum, which raises total serum thyroxine and unsaturated thyroxine-binding globulin, but does not affect free thyroxine levels (Aday et al., 2020). Some medications have lasting residual effects that can interfere with tests, such as biotin, which is commonly given in high doses. Refer to individual test guidelines for details on drug interference (Ciaccio et al., 2023).

Step 4: Documentation and Requisition: Accurate documentation is essential in the specimen collection process. This includes filling out a lab request form or requisition with key details like patient identification, date of birth, collection date and time, specimen type, requested tests, and any relevant patient history. Proper documentation ensures that the lab processes and interprets the sample accurately (McCudden et al., 2020). This communication between healthcare providers and the lab supports appropriate patient care based on the test outcomes (Prasad, 2022).

Step 5: Specimen Reception and Laboratory Testing: When specimens arrive at the lab, they undergo a reception process. This involves verifying that the specimen matches the requisition details and checking for container integrity and expiration (Lebas et al., 2022). After reception, various laboratory tests are performed. Blood samples may be used for glucose level assessments, complete blood counts, or cultures to detect pathogens. Urine samples might be tested for bacteria, glucose, or undergo PCR testing for specific diseases. The testing depends on the doctor's request, patient symptoms, and specimen type (Tseng et al., 2023).

Step 6: Specimen Disposal and Patient Follow-up: After testing, any remaining specimen is disposed of according to local and federal regulations, ensuring the safety of healthcare professionals and the environment (Cornish et al., 2021). Finally, healthcare professionals review test results with the patient and discuss next steps, which could include new treatments, additional testing, or ongoing monitoring (Hwang et al., 2022).

Chapter 4: Enhancing Collaboration between Nurses and Laboratory Staff

The efficiency of healthcare delivery is strongly linked to the quality of interprofessional communication and collaboration among healthcare workers (Zajac et al., 2021). Collaboration in healthcare involves each professional effectively embracing complementary roles within a team, working cooperatively, sharing problem-solving responsibilities, and making decisions to develop and execute patient care plans. Interprofessional collaboration between laboratory staff, nurses, and other team members enhances the collective understanding of each member's unique knowledge and skills (Alhawsawi et al., 2023.)

Collaboration among healthcare team members is vital for improving patient outcomes and enhances the quality of care through better decision-making (McLaney et al., 2022). Specifically, collaboration between nurses and laboratory staff is critical for delivering high-quality patient care. Nurses focus on direct patient care, while laboratorians ensure that instruments function correctly before patient testing, ensuring accurate results. Improving communication and professional relationships between clinicians and laboratory staff fosters greater trust in diagnostic tests, increasing the effective use of lab diagnostics and ultimately enhancing patient care (Hakami et al., 2022).

In today's healthcare environment, laboratories play a key role in ensuring effective care transitions and fostering reliable relationships within a constantly evolving system that demands continuous quality improvement, patient safety, and a focus on patient needs (Montano et al., 2023). Nurses and laboratory personnel can meet these demands by collaborating to achieve better patient outcomes. By understanding each other's roles and contributions, both nursing and laboratory staff can identify ways to work together more effectively (Wondirad et al., 2020).

Benefits of Collaboration between Nursing and Laboratory Staff: Direct communication between nurses and laboratory staff, such as nursing consultations with lab personnel on wards, bridges the gap between lab results and patient-centered outcomes, allowing for discussions about test procedures and interpretations relevant to the patient (Asamrew et al., 2020). This interaction, termed "post-analytic testing," involves analyzing laboratory test results alongside patient symptoms and likely diagnoses. Activities range from educating nurses on which tests to request and proper specimen collection techniques (Brooks et al., 2022) to formal consultations with both nurses and patients about test findings and subsequent steps. Clear communication and addressing any uncertainties in test results lead to better patient care by reducing medical errors, time to diagnosis, and unnecessary testing or treatment (Gibani et al., 2020). Due to the importance of patient safety and outcomes, research in post-analytic testing and the relationship between lab tests and patient outcomes is crucial (Klucher et al., 2022).

The success of nursing-laboratory collaboration in improving patient diagnosis and treatment is often measured by changes in test effectiveness and patient morbidity and mortality rates. Improved diagnosis and treatment are closely tied to nursing involvement in laboratory processes (Iyengar et al., 2020). Given the essential role of laboratory testing in patient care, it's important for nurses to gain knowledge of laboratory science and the function of lab services, allowing them to interpret findings and use them to enhance patient outcomes (Ma et al., 2021).

Nurses play a vital role in translating medical diagnoses into patient-centered outcomes, making it essential for those working closely with patients to understand the diagnostic process and connect test results with treatment plans (Sole et al., 2020). The advantages of collaborative relationships between nurses and lab staff, as highlighted by studies and commentaries, include improved diagnosis and treatment, better communication and information exchange, and a streamlined workflow (Raurell-Torredà et al., 2021).

Improved Patient Diagnosis and Treatment: For nursing to play a more significant role in patient diagnosis and care, collaboration with laboratory professionals must improve (Pairo-Castineira et al., 2021). In the fast-paced healthcare environment, having a solid understanding of practical actions and their impact is crucial for guiding interventions that improve patient outcomes, particularly with diagnostic testing and patient monitoring. By identifying patient needs and delivering nursing care, nurses can support more targeted and efficient use of laboratory services, leading to better diagnosis and treatment (Catania et al., 2021).

Enhanced nursing education on testing services and the development of evidence-based guidelines for test indications and timing can improve test utilization (Umubyeyi et al., 2021). Effective communication with laboratory professionals, sharing patient information and discussing appropriate tests, leads to more relevant testing and minimizes the ordering of inappropriate tests. Delays in patient diagnosis due to lost samples, misplaced request forms, or unperformed tests are common in laboratories (Almalki et al., 2022).

As interprofessional collaboration strengthens, nurses increasingly engage in all aspects of healthcare, transforming the traditional view of nursing into one that emphasizes diagnosis and care (Alshammari et al., 2022). Improved communication and information sharing involving laboratory staff in patient diagnosis and treatment enhance the process's efficiency. Although laboratory testing guides clinical decisions, issues arise when clinicians are unaware of the correct test, tests are unavailable, or patient identification for tests is unclear (Almarwani et al., 2023).

Although efficiency gains from early diagnosis or preventing misdiagnosis may not always be quantifiable, they contribute to better patient outcomes (Nielsen, 2020). By collaborating with nursing staff, laboratory personnel can participate in initial diagnosis and treatment planning, often through consultation when ordering tests or attending multidisciplinary meetings. Technological advances, such as electronic medical records, now facilitate communication between laboratory and nursing staff, reducing reliance on telephone, pneumatic tube, or face-to-face interactions (Srivastava et al., 2020; Manookian et al., 2022).

Streamlined Workflow and Efficiency: Nurses and laboratory technicians improve patient outcomes by working collaboratively. One primary method of optimizing the laboratory process is through nurses' understanding of specimen collection requirements and techniques (Naidu et al., 2021). Nurses are usually responsible for sample collection, and inaccuracies can impact patient care, necessitating redraws or risking treatment decisions based on faulty results. Proper sample collection improves lab efficiency and patient care, leading to high performance in procurement (Simundic et al., 2020). If the laboratory understands nurse preferences regarding specimen collection, it can process samples more efficiently. Communication between nurses and the lab can determine whether to delay tests until patient stability is confirmed, preventing unnecessary calls and misunderstandings about test cancellations (Farokhzadian et al., 2020).

Strategies for Effective Collaboration: Improving communication between nursing and laboratory staff is vital to enhance interprofessional relationships. Strategies include full information sharing, promoting nursing-laboratory rounds, and incorporating laboratory services into nursing care teams. Methods for managing critical lab value reporting and overcoming communication barriers are essential (Goulding et al., 2020). Understanding the system where information is exchanged and identifying improvement areas can help tailor interventions to specific units or organizations (Goulding et al., 2020).

Establishing Clear Communication Channels: Communication is a dynamic, complex process that connects individuals, involving encoding information, selecting transmission methods, sending and receiving messages, and providing feedback (Hayan et al., 2022). Effective communication occurs when the sent and received messages match. Communication can be verbal (spoken or written) or non-verbal (body language, facial expressions, or gestures) (Almutiri et al., 2023).

Effective communication facilitates the exchange of information, ideas, and emotions, allowing needs to be expressed and enhancing service delivery. Job satisfaction and performance are often linked to effective communication (Alsharkh et al., 2023). Moreover, communication promotes both personal and professional

growth, while poor communication frequently causes conflicts and misunderstandings in clinical settings, often due to inadequate communication (Alenezi et al., 2022).

Developing Shared Protocols and Guidelines: Creating shared protocols and guidelines requires collaborative input from nursing and laboratory staff. A joint committee with representatives from each field is an effective way to start, with responsibility for drafting these protocols and guidelines (Dora, 2020). A facilitator may help keep the committee focused, ensuring relevant issues are addressed. The committee should identify specific areas in patient care needing protocols, prioritize them, appoint subcommittees to draft and distribute guidelines, and track progress (Alsary,).

Shared protocols and guidelines enhance patient care by reducing inappropriate tests and misinformation when reporting findings, leading to better-quality care with timely, accurate information (Chandrasiri & Weerakoon, 2022). It's important to remember that these protocols require periodic review to remain evidence-based and aligned with current practices (Tomczyk et al., 2021). Shared protocols and guidelines have identified as essential components for improving collaboration between nurses and laboratory staff. They are important for two main reasons. Firstly, they are important to ensure that both professions operate on a level defined by released constraints. The use of protocols and guidelines will allow each profession to define their scope of practice and offer understanding of limitations **(Reed & Ferdig, 2021).** Protocols and guidelines can also be used to clearly define when each profession should report findings or problems. For example, a recent study of Critical Care nurses and laboratory staff found that critical care nurses often did not recognize or follow-up abnormal laboratory results **(Hajirasouliha & Elemento, 2020).**

Inaddition, This occurred because critical care nurses were often unsure of the significance of the results, and if indeed the tests undertaken were sensitive or specific to the patient condition. By having protocols set by both professions, this can be avoided **(Alhumaid et al., 2021).** Conducting regular interdisciplinary meetings, The regular meetings are an effort for the clinical nurses, nursing management, and professional nurses and laboratory technicians Regular meetings can also provide a focus for a collaborative project designed to measure and evaluate the effectiveness of changing practice on patient outcomes **(Arifin, & Mohd-Yusof, 2022).**

Chapter 5: The Impact of Technology and AI in Laboratory Diagnostics Diagnostic Processes

Artificial intelligence (AI) refers to the capability of machines or software to mimic human intelligence, perform instant calculations, solve problems, and evaluate new data based on past information (Varkey, 2021). AI significantly impacts various industries, such as agriculture, manufacturing, autonomous vehicles, fashion, sports analytics, and healthcare. While AI has the potential to shape the future of industries and humanity, it presents both benefits and challenges (Farhud & Zokaei, 2021(.

In healthcare, AI applications have transformed the field, particularly in imaging, electronic medical records (EMR), laboratory diagnostics, treatment, augmenting physician intelligence, drug discovery, preventive and precision medicine, extensive biological data analysis, process efficiency, and data storage and access for healthcare organizations (Mirbabaie et al., 2021). Despite its advancements and contributions to improved healthcare, AI also faces ethical and legal concerns and remains inaccessible to certain populations (Sharma et al., 2022).

Medical AI development focuses on assisting clinicians with diagnosis formulation, therapeutic decisions, and outcome prediction. This technology represents a major shift in healthcare, driven by the vast availability of healthcare data and advancements in analytical techniques (Smith & Kirby, 2020). Laboratory medicine increasingly adopts new technologies for clinical decision-making, disease monitoring, and patient safety. Clinical microbiology, for instance, applies AI to analyze genomic data from isolated bacteria, metagenomic data, mass spectra from bacterial isolates, and digital images, creating vast datasets for AI-based diagnosis (Undru et al., 2022).

AI in the laboratory setting capitalizes on computers' ability to identify complex, non-linear associations that may be challenging for humans to recognize. Since AI processes information differently than humans,

it can provide more advanced diagnostic and prognostic models, pushing analytical capabilities beyond human limits (Naugler & Church, 2019). Additionally, AI plays a key role in analyzing large datasets in fields like chemistry, hematology, and other laboratory medicine specialties (Olivera et al., 2019).

Big data, characterized by the four V's: Volume, Variety, Velocity, and Value, includes massive datasets like the millions of test result data points generated annually by clinical laboratories. These datasets, often linked to electronic medical records, are too extensive for traditional statistical methods (Ngiam & Khor, 2019). AI-based tools have recently demonstrated their effectiveness in utilizing big data to enhance public health management and support healthcare decision-making (Khatab & Yousef, 2021).

AI aims to replicate human cognitive processes, marking a shift in healthcare through the availability of extensive healthcare data and advances in analytical techniques (Sebastian & Peter, 2022). AI techniques range from machine learning methods for structured data, like support vector machines and neural networks, to modern deep learning and natural language processing for unstructured data. These AI tools are extensively used in fields such as oncology, neurology, medicine, and cardiology (Undru et al., 2022).

AI excels in managing large volumes of patient data with efficiency and reliability, surpassing human limitations. It addresses challenges arising from individual variability and fluctuations in clinical data, enabling accurate disease diagnosis and potentially advancing personalized treatments (Rajkomar et al., 2019). In clinical laboratories, AI automates processes, improves care quality, enhances testing efficiency, and provides consistent results. Extensive genome sequencing over the last decade has highlighted significant genetic diversity, emphasizing the importance of personalized treatments and medications tailored to each patient's unique characteristics (Poalelungi et al., 2023).

AI also shows promise in managing and preventing chronic diseases (Subramanian et al., 2020), including accurate stroke prediction (Bonkhoff & Grefkes, 2022), cardiovascular disease (CVD) prediction, and personalized cancer treatments. In clinical labs, AI aids in sample collection, storage, and retrieval, reducing the need for human resources and saving time. Automated systems lower the requirement for manual specimen processing, streamlining review processes and enabling additional testing where necessary. AI reduces errors in pre-testing stages by addressing issues related to hemolysis, lipemia, and jaundice (Chen et al., 2021).

For example, AI has been successfully applied to blood collection processes, electronic medical record management, and using artificial neural networks (ANNs) for sample retrieval, dilution, and retesting. Traditionally, clinical microbiology relies on manual detection of pathogens under a microscope (Janett & Yeracaris, 2020). However, integrating technology with clinical microbiological images enhances efficiency, patient management, and detection accuracy. A notable case is the use of an advanced AI imaging system, which significantly reduces the time needed to analyze culture plates (Crispin et al., 2022).

Bokhari et al. (2022) developed the Chromo Enhancer model, which enables robust routine cytogenetic analysis and accurate detection of recessive chromosomal abnormalities by generating high-quality cytogenetic images. Islam et al. (2020) designed a deep learning-based automated model to cut costs by reducing incorrect orders. Mao et al. (2022) created an intelligent medical system using a Graph Convolutional Network to recommend drugs based on incomplete lab tests and accurately estimate missing values. Burton et al. (2019) applied algorithms for urinary tract infection screening in clinical microbiology, reducing culture workload by approximately 41% by avoiding unnecessary culturing of negative samples.

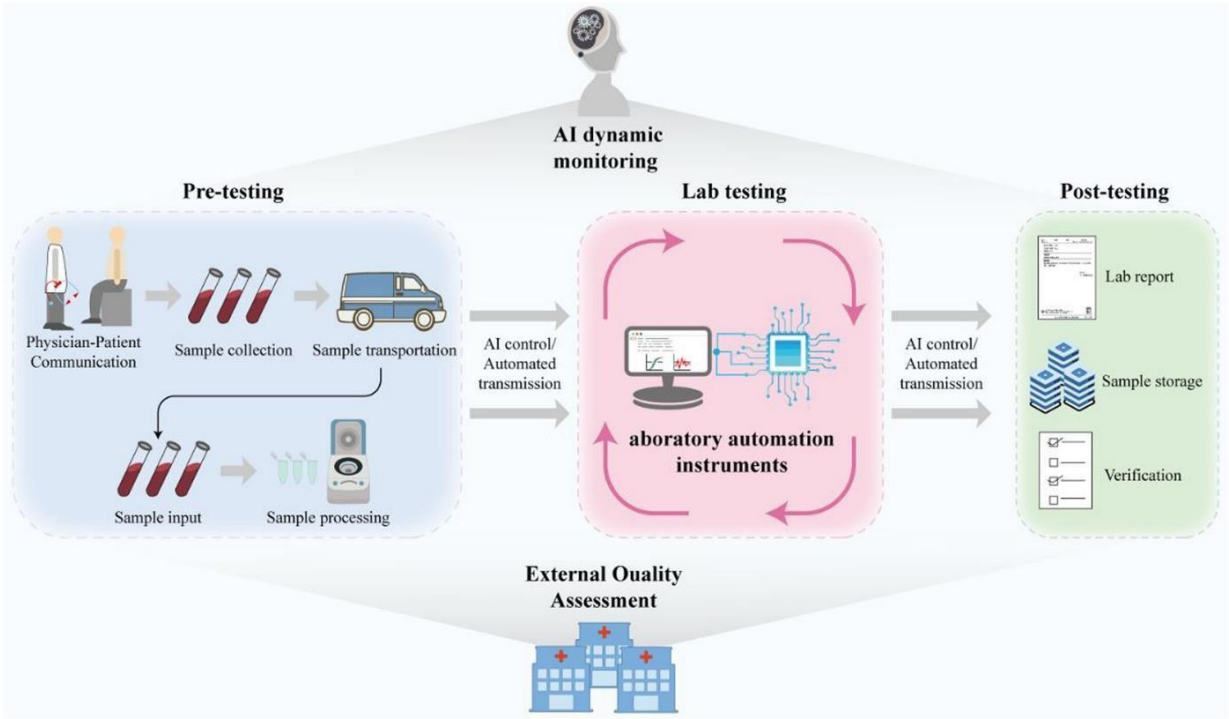

FIGURE (2): Integration of artificial intelligence in clinical laboratory

Xie, H., Jia, Y., & Liu, S. (2023). Integration of artificial intelligence in clinical laboratory medicine: Advancements and challenges. *Interdisciplinary Medicine*, e20230056.

AI is now integrated into the entire process of clinical laboratory testing. In the pre-test phase, AI plays a role in sample identification and transportation (Farrell, 2021). The samples then undergo automated testing, where AI is involved in the testing process and quality control. In the post-testing stage, AI contributes to reporting results, sample storage, and more. The complete testing workflow is dynamically monitored by AI and evaluated through external quality assessments (Xie et al., 2023).

The pre-testing phase includes test requests, patient and sample identification, blood collection, sample processing, and transportation. This phase is particularly error-prone, as it occurs outside direct laboratory oversight. AI's role in pre-testing has significantly reduced errors in laboratory testing (Lee et al., 2019). An automated camera system with optical character recognition detects labeling errors in patient samples, while a machine learning (ML) model identifies incorrect blood samples in complete blood count results (Farrell & Giannoutsos, 2022).

Recently, Yang et al. (2022) developed a deep learning (DL)-based system to assess serum quality by analyzing sample images. They trained a DL model using 16,427 images of centrifuged blood to predict serum index values and distinguish samples that meet criteria, fail, or show interference. This system successfully identified abnormal samples, including those with hemolysis, jaundice, and lipodystrophy. Additionally, Fang et al. (2021) created an ML model using a neural network to evaluate coagulation status in undetected blood samples, aiding in sample quality assessment and enhancing laboratory automation.

In the testing phase, various specimens are analyzed. Digital scanning and image feature extraction allow precise identification of abnormalities and rapid error detection in laboratory analysis (Schork, 2019). During the post-testing phase, AI can promptly detect abnormal reports and initiate corrective actions. Algorithms generate “personalized” reference intervals based on patient-specific data, reducing the risk of missed diagnoses or misdiagnoses (Ma et al., 2022).

A machine learning algorithm interprets patients' urine steroid profiles automatically. An AI system using a tree-based algorithm was developed to verify laboratory test results automatically, achieving 99.9% sensitivity, 98% specificity, and reducing invalid reports by 80% (Wang et al., 2021). Additionally, a neural

network-based algorithm evaluates biochemical test results with critical values, reaching a sensitivity of 91% and specificity of 100%. Patient-based real-time quality control (QC) effectively monitors the consistency and stability of laboratory testing in real-time, identifying and analyzing errors promptly (Lu et al., 2022).

Additionally, it facilitates real-time monitoring, recognition, and early warning of various quality risks in various specialized domains of clinical testing within the laboratory **(Li et al., 2022).** Apart from QC, external quality assessment (EQA) plays an essential role in evaluating laboratory capabilities and comparability. EQA is instrumental in upholding and improving the quality of laboratory services. Given that different EQA schemes might have unique acceptance criteria **(Badrick, 2021).**

Chapter 6: Best Practices and Protocols for Patient Safety in Diagnostics

Laboratory medicine is now recognized as a fundamental component of clinical decision-making in healthcare (Plebani et al., 2019). Ensuring patient safety in laboratory medicine involves preventing harm to patients, enhancing safe care outcomes through error prevention, and continuously improving the total testing process (TTP). Therefore, medical laboratories need effective quality assurance measures to identify and prevent errors, ensuring reliable laboratory information (Plebani et al., 2021).

Although the goal is to achieve zero errors in patient safety, laboratory professionals have made significant efforts over the years to reduce errors. Yet, research on laboratory-related diagnostic errors reveals that mistakes occur at every stage of the TTP, particularly in clinical interface phases. Despite strategies to improve analytical quality, it remains a challenge, and errors are linked to both traditional clinical chemistry tests and increasingly complex diagnostic tests (Dash et al., 2021). To improve quality and reduce errors, laboratory professionals must understand the impact of their results on patients, while clinicians need to be aware of the tools used in laboratories (Fischer et al., 2021).

Laboratory medicine is generally regarded as low-risk compared to specialties like emergency and intensive care, as laboratory processes are clearly defined and more easily controlled than procedures in emergency settings, which rely heavily on healthcare professionals (Gens-Barberà et al., 2021). However, laboratory errors can be subtle and difficult to detect immediately, as they involve multiple steps, providers, and time lags between testing, physician action, and patient outcomes (Yali & Nzala, 2022).

Understanding the types, frequency, causes, and impact of errors is essential to implementing control measures that prevent failures and reduce risks. In laboratory practice, the definition of "error" has evolved along with organizational changes in laboratory processes and testing (López Yeste et al., 2021). Risk management, a systematic process to identify and manage actual and potential risks in laboratory testing, is becoming a key component of quality management systems and plays a vital role in delivering quality services (Villar et al., 2021).

Pre-Collection Guidelines: Proper sample collection for microbiology testing is crucial, as errors at this stage are irreversible and may require recollection. Documentation should confirm that the patient was prepared correctly before specimen collection (Ferorelli et al., 2020). A laboratory request form with essential information should accompany the specimen to aid result interpretation and reduce errors, including the patient's name, date of birth, hospital number, ward or department, specimen type and source, collection date and time (Sonmez et al., 2020).

Additionally, details on the diagnosis, patient history, and reason for testing, such as recent travel with symptoms like diarrhea or vomiting, presence of catheters, or surgical details, should be included. Information about any antimicrobial drugs administered is also necessary (Azyabi et al., 2021). The request should list the ordering clinician's name and contact number, as preliminary results may need to be communicated for early treatment discussions. Standard precautions require hand washing before and after specimen collection, and appropriate personal protective equipment should be worn when handling specimens (Niv & Tal, l2023).

Specimens should be collected in sterile containers with close fitting lids to avoid contamination and spillage. It is not necessary to collect stool specimens in a sterile container. All specimen containers must be transported in a double-sided, self-sealing polythene bag with one compartment containing the laboratory request form and the other the specimen (Zhong et al., 2021). Ideally microbiological specimens should be collected before beginning any treatment such as antibiotics or using antiseptics. However, treatment must not be delayed in serious sepsis. Transport medium may be used to preserve micro-organisms during transportation (Sittig et al, 2020).

Tenets of Specimen Management, It is important to be knowledgeable of caveats that are relevant to specific specimens and diagnostic protocols for infectious disease diagnosis (Shander et al., 2022). However, there are some strategic tenets of specimen management and testing in microbiology that stand as community standards of care and that set microbiology apart from other laboratory departments such as chemistry or hematology. Ten points of importance are: The laboratory should set technical policy; this is not the purview of the medical staff. Good communication and mutual respect will lead to collaborative policies (Park et al., 2023).

The laboratory must follow its procedure manual. A specimen should be collected prior to administration of antibiotics. Once antibiotics have been started, the microflora change, leading to potentially misleading culture results. Specimens must be labeled accurately and completely so that interpretation of results will be reliable (Schnock et al., 2022). Labels such as "eye" and "wound" are not helpful to the interpretation of results without more specific site and clinical information (eg, dog bite wound right forefinger). Microbiology specimens should be delivered to the testing laboratory without delay, and according to the lab's requirements for specimen transport and stability (Zaidi et al., 2022).

Background noise must be avoided where possible. Many body sites have normal flora that can easily contaminate the specimen. Therefore, specimens from sites such as lower respiratory tract (sputum), nasal sinuses, superficial wounds, fistulae, and others require care in collection. The laboratory requires a specimen, not a swab of a specimen (Han et al., 2023). Actual tissue, aspirates, and fluids are always specimens of choice, especially from surgery. A swab is not the specimen of choice for many specimens because swabs pick up extraneous microbes, hold extremely small volumes of the specimen (0.05 mL), make it difficult to get bacteria or fungi away from the swab fibers and onto media, and the inoculum from the swab is often not uniform across several different agar plates. Swabs are expected from nasopharyngeal and viral respiratory infections (Nnate et al., 2021).

Specimens of poor quality must be rejected. Microbiologists act correctly and responsibly when they call physicians to clarify and resolve problems with specimen submissions. Physicians should not demand that the laboratory report "everything that grows," thus providing irrelevant information that could result in inaccurate diagnosis and inappropriate therapy (Ayisa et al., 2021). Susceptibility testing should be performed on clinically significant isolates, not on all microorganisms recovered in culture. Microbiology laboratory results that are reported should be accurate, significant, and clinically relevant (Dynan & Smith, 2022).

The microbiology laboratory policy manual should be available at all times for all medical staff to review or consult. It would be particularly helpful to encourage the nursing staff to review the specimen collection and management portion of the manual. This can facilitate collaboration between the laboratory, with the microbiology expertise, and the specimen collection personnel, who may know little about microbiology or what the laboratory needs in order to establish or confirm a diagnosis (Aggarwal et al, 2021). Most infectious disease protocols have based their strategies on the management of results generated by microbiology laboratories. Getting the right diagnosis is contingent upon laboratory results that are accurate and clinically relevant. (Gohar& Nowrouzi-Kia, 2022).

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